the tea less. Machines depending on an air-blast such as the deflector type of machine are the least liable to grey the teas. One cause for the greying of tea is the speed at which the cutters or breakers are run. A fast run machine will tend to grey the teas much more than one run slower, and consequently such machines should be run at the slowest speed that is compatible with efficiency. One often sees such machines run at too high a speed in order to get through the amount of work whereas what is really required is another machine so that the two machines may both work at proper speeds.

During the sorting tip is very easily destroyed, consequently to obtain a tippy finished tea it is necessary that the fine mal should be subjected to the very least possible amount of sorting and cutting.

THE

Indian Tea Association.

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL.

PART III.

1926

Calcutta:
PRINTED AT THE CATHOLIC ORPHAN PRESS,
3 & 4, PORTUGUESE CHURCH STREET.

1926.

SHADE TREES.

BY

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Shade trees have now been used for many years in tea cultivation, and general opinion is undoubtedly strong that their use is favourable to the growth of tea. Undoubtedly tea growing under shade is practically always better than tea in the same immediate neighbourhood without shade; but conclusions founded on this observation may be vitiated by the fact that the unshaded area very often has no shade because the attempt to establish shade trees has failed simply on account of poor soil. For the same reason tea under good shade trees may be better than tea under poor shade trees.

There are, however, many cases of unshaded and shaded areas of which there is every reason to believe the fertility similar, and in such cases the shaded area almost invariably carries the better tea.

The general conclusion therefore is that under conditions normal to the average garden, it is advantageous to plant shade trees.

It is clear on the other hand that there are disadvantages attending the use of shade trees, of which the labour and expense necessary for their establishment are not the greatest. It is also clear that absolutely first-class tea can be grown without shade, for example some of the tea at Tocklai and Borbhetta Experimental Stations, and on several gardens on a commercial scale, notably a garden, which is a strong candidate for first position in Assam for yield and quality combined, where there are literally no trees at all except a few Simuls left at the original planting.

At Tocklai and Borbhetta the plots have to be unshaded on account of their small size. The presence of a tree would affect many plots, and would affect them unequally and so mask the

effect of the treatment under trial. Actual experiments on shade trees would require plots of very large size, which are not available on the small areas of either Experimental Station. Direct experiments therefore are not available for the purpose of deciding the importance of each factor which comes into play, but it may be of value to discuss the available evidence regarding the use of shade trees in order to correct any misconceptions which may exist, and to enable us to form theories which may assist decisions as to the conditions under which the trouble and expense of planting shade trees are likely to be repaid, and may be useful starting points in the search for further knowledge.

Shade trees may do good in any or all of the following ways :—

(*i*) By the addition of plant food to the soil.

The evidence in support of the assumption that leguminous plants excrete fertilising material from their roots, is very slight indeed. A leguminous plant is a better neighbour for tea, than another tea bush, but tea undoubtedly suffers from the presence of any plant in place of clean soil around it. The improvement of the soil under shade trees must be looked upon as coming practically entirely from the leaves annually falling to the ground, in which they become buried by cultivation.

Any mineral food such as potash and phosphoric acid must have come from the ground to which it is returned; but it is returned in a more readily available form, and hence the soil is somewhat improved as a provider of these food materials.

The whole of the carbonaceous organic matter came from the air and this very valuable soil constituent is wholly a gain to the soil on which it falls.

The nitrogen, in the case of leaves from leguminous trees, also came largely from the air, and therefore should enrich the soil in this constituent. Analyses of soils under old shade trees show always a distinct enrichment in their organic matter, but little, if any, increase in their nitrogen content. It does not follow, however, that the soil has not gained from the extra

nitrogen; but this constituent has probably been used, as fast as it was added, to build up the improved tea bushes found.

All these soil improvers could be added as manure in the form of combinations of artificials and either green crops or cattle manure, and where these are used in sufficient quantity there is no need to use shade trees for that particular purpose.

Where however little or no manure is used, shade trees are of enormous value in maintaining the fertility of the soil. There are gardens which, on account of their shade trees, have maintained good yields over many years with little or no other fertilizer expenditure than on planting shade trees.

(2) Shade keeps down jungle.

The deep-rooted, coarse, high-growing grasses, which are the very worst of the enemies of the tea bush, will not long persist under good shade trees, but their place is taken by shallow-rooted fine grasses and by other shallow-rooted weeds such as Ageratum. These latter do relatively little harm, and have the great advantage of being easily removed when cultivation is put in.

On long-neglected gardens one finds, in the open, poor, stunted bushes growing among thatch-grass; while here and there, where there happens to be a clump of two or three shade trees or a single big one, one sees really good tea growing amongst shallow-rooted low grass. One never sees such a marked difference on gardens which have always been kept clean. In fact on areas where tea naturally grows so vigorously as to keep down its own jungle, the tea under such shade trees as there are, may be dark and healthy looking, and carry longer flushing shoots, but will not always carry such a thick, yielding flush as tea away from the shade trees.

From the point of view of jungle of suppression, then, shade trees have a very high value when cultivation is deficient, but a small value only on a garden which is always practically clean.

(3) Root-action.

By root-action is meant the penetration of the soil by roots which open it up to the action of air and water and carbon dioxide (excreted by the roots) and induce the soil to " weather."

The top-soil is commonly darker than the subsoil, but where even a single tree-root penetrates the subsoil, then the subsoil immediately surrounding the root will also be dark.

The depth of good soil on a garden is very much the same as the depth of the average root of the jungle which was growing before the land was cleared. Hence, tree-jungle gives a deeper soil than grass land, and tree-jungle on land where the root-range is limited by a high water-table will give a shallower soil than tree-jungle on naturally well-drained land.

Where there is a tendency to the formation of pans in the soil, the presence of good shade trees, planted before the pan formed or after it was broken, would prevent pan-formation. Shade trees roots however will not penetrate and break a pan. Where the root range of tea is limited either by the presence of a pan, or by a high water-table, then shade tree roots will be equally limited. All the shade trees used in tea have a greater tendency to grow shallow horizontal roots than the tea bush itself, and where anything limits the depth of roots, then the " root-action " of a shade tree is simply to occupy surface soil which might more profitably have been occupied by tea-roots.

The digging of holes to plant shade trees would break a pan, and the planting of shade trees would prevent the re-formation of the pan. So also would the planting of a vigorous tea bush.

The planting of shade trees is no substitute for deep-drainage when required.

With regard to these three factors, then, (1) addition of plant food, (2) effect in suppressing jungle, and (3) root-action, shade trees are of value when it is desired to save expenditure on cultivation and manuring by other means, but shade trees

can very well be done without when really first class tea is being grown with the help of thorough cultivation (which means that jungle is suppressed) and manuring. There remains however another factor to be considered—

(4) Effect of shade on the tea bush itself.

A certain amount of shade is undoubtedly beneficial to tea. This is particularly noticeable during hot dry spells when the sun's heat is very intense. Such a spell was experienced in May and early June of this year. The comparison between tea with and tea without shade was then very striking indeed, and it made no difference whether the shade was due to a tree or to an inanimate wall.

The efficiency of this factor depends mainly on the relief from scorching by the sun. By keeping the air cooler, also, shade trees maintain a more saturated atmosphere under them, than is found in the open; and this moisture of the air is further increased by the water transpired through the leaves of the shade trees.

Sunshine is good and necessary for tea but it is sometimes excessive, and when it is so for a long period, tea which is in any way weak will be subject to brown-blight, copper blight, red rust, die-back diseases, and the combination of fungoid ills known as rim-blight. It may also show the peculiarly stunted growth popularly associated with green fly attack. Red spider may show up badly.

All these evils are always greatly reduced, and in many cases are avoided altogether by the use of shade trees, so that a great deal of loss may be saved.

This effect of shade in reducing sun-scorch is naturally more marked in districts subject to long dry spells. It is for example more marked in South Sylhet than in Assam; while in Dehra Dun and Ranchi, it is the opinion of Mr. Carpenter that the provision of shade is absolutely essential and that the chief part of its good effect in those districts lies in keeping off the sun.

The diseases at Borbhetta, where there is no shade, were worst on :—

(*a*) Tea which had been cut back, particularly if the pruning was late.

(*b*) Young, unestablished tea.

(*c*) Light leafed varieties.

(*d*) The poorer soils, and soils which had not been manured.

Dark leafed tea, which had been well treated, was nowhere affected to any extent.

At Tocklai on much better soil, the better established and well-treated tea suffered little; but tea on areas of poor soil, and tea of light-leafed varieties were more or less attacked, whereas strong, dark-leafed tea on good and well-treated soil suffered not at all, and yielded very well.

Similar observations could be made anywhere, the inference being that fit, well-treated tea, particularly if of dark-leaf variety, is able to do without shade, at any rate, in Assam; but that cut-back tea, tea for any reason weak, and tea of light-leaf *jat* benefit enormously from actual shade, apart from the other benefits derived from leguminous trees.

The general conclusion from the available evidence, then, is that it is much easier to grow tea under shade than without it, but that if it were necessary, tea could be grown very well, in good climates without shade, so long as cultivation and manuring and general treatment are of the best, particularly if dark-leafed varieties are used.

Where shade is temporarily required as on young tea which is being established, or on tea which has been cut-back, including tea pruned after being unpruned, then use may be made of semi-permanent crops like Boga medeloa or Arhar.

Still it is clear that there must be shown very great disadvantages attending the use of shade trees on any particular

area, before it is decided that the very great advantages shall not be made use of.

That, on the whole, shade trees are of advantage is shown by an experiment carried out by Mr. Booker at Pabhoi Tea Estate.

The tea used for experiment had been planted in 1917, and at the same time one-year old Sau trees were put in at 30 ft. by 30 ft. At the end of 1922 an area of, to all appearance, very even tea was divided into 3 blocks treated as follows. All other treatment was the same for all blocks.

On No. 1 Block—Sau trees were left as planted, *i.e.*, 30 ft. by 30 ft. apart.

On No. 2 Block—Sau trees were thinned out so as to remain 30 ft. by 60 ft. apart.

On No. 3 Block—All shade trees were cut out.

The following yields have been obtained :—

	Yield in mds. green leaf per 5 acre plot.		
	1923.	1924.	1925.
Block 1. Heavily shaded; 30′ × 30′ ..	224	231	209
Block 2. More lightly shaded ; 30′ × 60′ ...	245	233	217
Block 3. Unshaded—nil	233	195	158

It will be noticed that there was not much difference in yield in 1923, from which it may be assumed that the soil of Block 3 was originally at least equal to that of the other blocks, while the probability is that loss from lack of shade had already been experienced and that block No. 3 had originally the best soil of the three blocks.

Block 1 has not improved relatively to Block 2, in spite of having more shade trees. The effect of the extra manure from leaf fall must have been counterbalanced by some adverse factor.

The drop in crop from the unshaded block is very marked.

The manager's remarks on the appearance of the plots are :—

Block 1. Excellent growth with nice healthy dark appearance with few twiggy shoots.

Block 2. Excellent growth, healthy but not so dark as No. 1. Very few twiggy and useless shoots.

Block 3. Healthy but very yellowish and nothing like so healthy in appearance as 1 and 2. Full of twiggy and banjhi shoots. Not so thick growth.

The tea was young, just coming into good bearing, on a good sandy virgin soil. It has not been manured. The soil had been well cultivated and on account of the wide spread of the bushes grew little jungle.

In this case the undoubted gain may be ascribed partly to the manurial effect but most largely to the direct effect of shade on the tea bush.

All plots were only slightly cleaned out. Shade by encouraging the growth of the stronger shoots makes less cleaning out necessary.

On these plots it is probable that the absence of shade on Block 3, might have been made up for by a combination of manuring, and better cleaning out. Possibly somewhat lighter plucking would also have been necessary to maintain a state of health equal to that of the shaded areas.

Crops equal to that from the shaded area, however, could only have been made at increased cost, and this experiment illustrates, very well, the general value of shade trees.

Monthly reports on the teas made gave a decided preference on the whole to the more slightly shaded area (No. 2 Block) in 1923, the unshaded block being a fairly steady second.

In 1924 each report was to the effect that there was "very little in it" between the three samples, but No. 3 (no shade)

gets decided preference in July and December, and No. 1 (full shade) in October, when No. 3 is picked out for briskness, but is found without colour and substance. In 1925, No. 3 (no shade) easily leads in July, August and September, but is again reported on in October as being light and thin. No. 2 (medium shade) generally held second place, but was placed first in June.

The 1925 reports, are probably the most significant since the bushes have had three years of different treatment.

On the whole quality at Pabhoi appears to be improved by absence of shade. Tea from unshaded bushes was frequently referred to as "light," but briskness, pungency, tip and occasional flavour are more often associated with unshaded tea. The preference given to unshaded tea is most marked during the rains, when tea under shade grows vigorously with perhaps a tendency to rankness. At the end of the season unshaded tea is generally less liked, and this may possibly be explained by its greater tendency to produce *banjhi* leaf. From the general tone of the reports, it is probable that there would have been little between the three blocks in average price over the three seasons.

DISADVANTAGES OF SHADE TREES.

The strongest objection to the use of shade trees may be seen on any garden where the shade trees are between 20 and 30 years old. Shade trees older than that are rare.

Old shade trees present a miserable appearance. On the commonest, the Sau and Koroi (*Albizzia stipulata*, and *Albizzia procera*), canker is the worst enemy, particularly on *stipulata*. The cankers are produced by a number of common fungi, and are generally the result of decreasing vitality of the tree. Branches are lost, trunks are blown down, and leaf becomes thin, so that the value of the trees as shade-givers becomes small. After about 20 years trees of any leguminous species die in large numbers, and often become attacked by root-diseases which also attack tea, and then the trees' widely-extended surface roots spread the disease throughout the tea. One of the commonest

causes of a high percentage of vacancies is the presence of dead trees.

When this occurs, the littering of the tea area with the dead and dying timber of old shade trees, vary much more than compensates for the value obtained during their earlier healthy life. To cut down the trees only makes matters worse. Those which were still alive die and become still more likely to contract root-disease and pass it on to the tea by the roots which remain in the ground. To dig out all the trees is very costly, nor can it be done without some further damage to the tea.

Many a man faced with this problem wishes that shade trees had never been planted on his garden.

The Mycologist suggests that the following procedure is the best way of dealing with the problem.

" Trench round the dead or dying trees in order to cut the
" main lateral roots, and with a rope (or a tree-pulling jack)
" pull the tree over. The falling tree will carry with it most
" of the uncut roots.

" Roots and branches will support the tree above the bushes
" and reduce the damage; but it is of course much better if the
" operation is performed before a heavy pruning of the tea.

" Fill in the hole immediately to cover the remaining roots
" with soil. The chance of infection by spores of root-disease-
" producing fungi are much reduced, and as a rule the roots
" decay harmlessly.

" The tree should be cut up and removed as soon as possible.

" If it is impossible to pull the tree over, the soil should be
" removed from the collar to allow the tree to be cut down at
" least a foot below the surface of the soil, so that the remain-
" ing stump can be well covered with soil and thus protected
" from infection by air-borne spores.

" In spite of such precautions some diseased roots will re-
" main in the soil. It will therefore be necessary to keep a
" careful look-out for cases of root-disease among the tea.

"Whenever an attacked bush is observed, it should be dug "out and removed together with, as far as possible, every bit "of dead wood from the soil in its neighbourhood."

On areas where shade trees are thickly planted, or where a dense mass of self-sown trees has been allowed to accumulate, all this involves considerable expense, and the use of a great deal of labour which often cannot well be spared.

Other minor drawbacks of shade trees are :—

(2) With the exception of *Albizzia mollucana* (the Ceylon Sau) all the common shade trees are deciduous, and do not come into leaf until after the hot dry spells so common in February, March and April. The Bor medeloa (*Dalbergia Assamica*) is indeed much later, and an old tree may give no shade till late in June. Transpiration, however, still goes on through the bark, and so during a dry spring the soil in the neighbourhood of a Sau tree is dried out and no compensation in the way of shade is obtained. After the drought of 1919, and on a lesser scale in 1922, 1923 and 1924, many bushes around Sau trees died from drought while those away from trees on the same section lived and finally came away healthily.

Deaths however usually occurred only in areas (*a*) where the depth of roots was limited by high water level in the rains or by a soil pan, so that shade trees and tea bushes were drawing water from the same shallow layer of soil; or (*b*) on extremely sandy soils which dried to a great depth.

In most cases the benefits due to manurial effect, and to shade during breaks in the rains, more than make up for the bad effect in dry springs; but on areas where roots must be shallow, shade should not be planted; for in such places they fill up the soil with spreading horizontal roots and do more harm than good. This, in the writer's opinion, generally applies to *bheel* soils and to low lying flats where the rains water level is high, particularly as in such situations shade trees will not long

remain healthy. On teelas, on the other hand, roots get well down, and the balance of the effects of shade trees is very much on the right side; particularly as on steep slopes, it is necessary to keep the soil in place by means of terraces or bunds, which will grow thatch. Attack on this thatch by hoes or other implements, very soon leads to the breaking and final loss of the terrace or bund. It is very much better to keep down this thatch by means of heavy shade. When the thatch has disappeared and been replaced by fine grass or other shallow rooted weeds, the shade trees could be dispensed with, if by that time the tea covers the soil. On southern and western slopes, however, shade is always very valuable in reducing the damage by excessive sun.

In many gardens in Cachar nearly all the shade has been cut out for fear of its supposed effect in increasing mosquito blight attack. On these gardens, wherever an old shade tree has been left, on a teela, the tea under it (although mosquito may sometimes collect there), is very much better and clearly gives much more leaf than tea in the open with no signs of mosquito attack.

On normally drained flats and areas of gentle slope the bad effect of a shade tree during a drought is not noticeable except on excessively sandy soils, and even on the sands the good effects of shade on the whole outweigh the bad.

(3) Shade trees compete with the tea for plant foods and for water, and exercise the normal bad effect of any plant growing to the neighbourhood of another.

On young tea or on poor tea where there is plenty of room for roots both of tea bushes and shade trees there is seldom any such noticeable bad effect on tea, but the reverse.

On high-yielding areas where the bushes literally touch, the bad effect of shade trees on bushes around them is often distinctly noticeable. The shaded tea looks very dark, but bushes are often noticeably thinner and do not carry the thick sturdy flush of a bush further from the shade tree.

Certain trees show this bad effect more strongly than others. Undoubtedly the leguminous trees show it far less than Silver oak (*Grevillea robusta*), Nahor or Nagessar (*Mesua ferrea*), *Ficus* species, and other non-leguminous trees such as are sometimes seen. Of the legumes the ordinary Sau (*Albizzia stipulata*) is undoubtedly much the best from this point of view, followed closely by the Koroi (*Albizzia procera*), which latter commonly keeps free from canker longer than the Sau. The Bor medeloa (*Dalbergia assamica*) also does little harm, but is very late in coming into leaf. Vigorously growing *Derris robusta*, however, has frequently been observed to be doing obvious damage to tea in its neighbourhood, and for this reason Derris should not be used unless it is known that other shade trees are too difficult to establish, in which latter case, Derris is very valuable as it will grow almost anywhere. When young this tree grows very rapidly, it becomes very bushy and carries a lot of leaf. As it grows older and taller its bad effect is much less noticeable. It is practically unattacked by canker, but its bark is often attacked by the grub of a beetle.

The Ceylon Sau, if left to grow naturally, grows very rapidly indeed, and is so bushy and leafy that it commonly does damage to surrounding tea. This tree however, is never attacked by canker, and therefore could be pruned. It is suggested that this tree might be cut to about 8 feet, when about two years old, and the resultant branches thinned and pruned back annually to keep the tree of the size and shape desired, so that it never becomes too big. A similar system is used with success in Java, where practically no other shade tree is used. Being an evergreen it gives shade all the year round, and when this is excessive it can be pruned.

(4) Effect on Quality.

It is quite certain that over-heavy shade reduces the strength and pungency of tea grown under it. Light shade has no noticeable effect in this direction. There may be a tendency to a small loss of quality even from light shade, but on ordinary plains

tea it is difficult to detect the difference, and any small loss there may be is certainly more than made-up by the gain in health and yield, of the tea bushes.

Method of using advantages of shade, while reducing drawbacks to a minimum.

Our general conclusion is that the vast majority of the areas under tea benefit, or would benefit, from shade, and that the chief disadvantage lies in the necessity of removing moribund trees after roughly sixteen years of useful life. From no point of view, however, is there any advantage in planting shade trees too thickly; in fact, particularly where quality is a consideration, the trees should be as far apart as possible provided that they give efficient shade.

When the trees are young it takes a lot of them to shade an area efficiently. For this reason, and also because some of those planted are expected to die soon, it is common to plant much too closely, 24 ft. by 24 ft., or even occasionally 12 ft. by 12 ft. The intention is to cut out some later on, but frequently the intention is forgotten till the trees are so big that the removal of the excess would be an expensive and troublesome matter, while merely to cut down the trees and leave the stumps is to invite trouble. In many cases the result is over-dense shade, and this is often intensified by the leaving of self-sown plants. Under such a forest of shade trees the tea obviously suffers even in yield, while good quality cannot be expected. When these trees begin to lose vitality, become attacked by disease, and start to die off, their removal is such a difficulty that it ought to be avoided by planting the minimum necessary at the start.

Where conditions are favourable the ordinary Sau tree, when mature, will provide quite sufficient shade if 60 ft. apart. Where shade is most necessary as in Dehra Dun and Ranchi, Mr. Carpenter's observations indicate that even there 40 ft. by 40 ft. is generally sufficiently close, but that trees should not be

further apart than that in those districts. From the writer's observation in N. E. India it appears that about 50 ft. by 50 ft. (or with triangular planting about 54 ft. apart) is a very fair average. At this rate only 18 trees to the acre are required. This number of tea bushes would never be missed, and it is preferable to plant shade-trees not between the rows of tea, but in place of a tea bush . . . . The shade-tree, while young, then has plenty of room to develop without interference by tea roots, it can be manured and otherwise looked after better, and has a better chance of growing healthily and well. So planted, also, it would not interfere with the use of buffalo-drawn cultivators which are so valuable in young or cut back tea. When the time comes for removal, it is not such a difficult matter if only 18 per acre have to be removed; and while they live, there is a chance that they may be looked after by the cutting out of canker and tarring of the wounds.

By planting the minimum number, all the other disadvantages of shade trees are also reduced to a minimum.

Wide-planted trees will be of little value while young and small, but may then be supplemented by boga medeloa.

Planting of Shade Trees.

Established trees left when the land is cleared for planting, remain healthy even when planted trees are dying off, while the planting and establishing of shade trees on new clearances of virgin soil present little difficulty.

Land growing poor tea which shade would most markedly improve, is generally the most difficult place to get good shade trees to grow in.

Many methods have been tried.

The planting of seed at stake usually fails because choked by jungle. It is extremely difficult to keep clean shade trees scattered over a wide area, particularly on a thatch-infested area where shade would do so much good.

Small seedlings are delicate and also suffer from jungle.

Trees so big that they have to be cut before carrying, almost invariably get canker at the cut. Even if protected by a dab of cow-dung, they usually die back for some distance, and get canker in the dead wood.

The best results are obtained from plants just so big that they can be carried and planted without cutting back.

Seeds sown in a nursery in the spring, produce plants just about the right size in early autumn; and this is also quite a good time for planting, while the soil is still moist, some rain may still be expected, and the weather is not very hot. In general, however, and particularly for districts where serious spring droughts are feared, it is better to wait till after the first spring rains before planting.

Several good planters have experienced their greatest successes by planting just after the young trees show their new buds.

In lifting from the nursery, a clod of soil must be left about the roots. It is, of course, all the better if the tap-root need not be cut; but it is most essential that the feeding surface roots, about the collar, should be left undamaged inside the clod of soil. When the tree is planted it will then go on feeding, and get little set-back.

The hole made ready for planting should of course be amply big to allow roots to be placed in it without bending. If soil has become detached from the lower roots the plant must be held upright, with the roots in correct position, while soil is placed and firmed around them.

If dry weather follows the planting, the young plants should be watered. When such a suggestion is made it is often considered impracticable; yet for 18 trees per acre half a dozen kerosine tins might provide sufficient water to make the difference between success and failure. The labour required to carry

an equal quantity (say 3 mds.) of manure would hardly be considered.

With regard to manure, cow-dung is excellent but suffers from disadvantages which do not apply to tea.

The white grubs (of cockchafers, and dung-rolling beetles) which are such a nuisance in the bungalow compound, and are brought in with fresh cattle manure, do not attack established tea, but are capable of eating off the roots of a young Sau tree and killing it. It is possible that cattle manure may carry fungus diseases which may attack young leguminous trees.

Only cattle manure which has been properly "made" (stacked and allowed to heat) should be used. About 10 lbs. of manure per plant is enough. This should be mixed before application with 4 ozs. of slaked lime, which is good for leguminous trees, though it may damage tea.

Failing good cattle manure a mixture such as—

2 ozs. bone siftings.
4 ,, oilcake
½ oz. sulphate of potash

per plant, would do excellently, or

5 ozs. animal meal
with 1 oz. bone meal

would do well.

Manures are most efficient on the surface, and are largely wasted by deep burial. The manure is best applied by forking into the soil about 4 to 6 inches deep in a wide circle outside the area occupied by the clod in which the tree was carried and planted.

If the tree is planted in place of a tea bush, it is much easier to see that the jungle is cleared from it whenever the tea is either forked or hoed, and it is much less likely to get sliced through by a hoe. It may however be necessary for some time after

planting to put in extra rounds of forking around the young shade trees only.

On goat and cattle infested areas, it will of course be necessary to basket the plants.

Shade tree nurseries require as much care as a tea nursery. They require shade during the dry months.

General Conclusions.

On low-lying flats shade trees very commonly do more harm than good.

On teelas or steep slopes, shade-trees are an absolute necessity, unless, or until, the tea bushes completely cover the ground. This is because shade reduces the necessity for loosening the sides of terraces or bunds (by cultivation to keep down thatch) exposing them to breakage and loss by wash.

On normally drained flats, and areas of gentle slope, wherever there is very poor tea unshaded, the establishment of shade trees will prove a relatively cheap and efficient means of improvement. The use of shade trees in normal situations allows moderately good tea (say seven to ten maunds per acre) to be grown for many years with little expenditure on other manures and at minimum cost for cultivation. When very high yields (say 15 to 25 maunds per acre) are produced by tea actually covering the whole of the ground, then there is no room for shade trees as well; but until this limit is reached tea will generally grow better with shade than without it.

Shade trees however exercise no good effect till they are about four years old, while when about twenty years old they begin to die off, and bring in root diseases; so that considerable loss of crop, trouble, and expense must be faced after about sixteen years useful life of the shade trees.

Tea so good that it does not require shade trees can only be produced when fed either on naturally very fertile soil or by

very good manuring and cultivation. For tea already very good it is probably better by manuring and other treatment to make it so good that it can do without shade than to run the risk of planting trees.

Where shade trees are planted their disadvantages, including the necessary expenditure for their subsequent removal, may be reduced to a minimum by using as few trees as will give efficient shade. 50 ft. by 50 ft. is suggested as sufficiently close for well grown trees on flat land. For slopes the distance apart would vary with the steepness of the slope and the direction in which it faces.

Those places which would benefit most from shade trees, are usually places where it is most difficult to establish them. Methods of planting are discussed.

Where it will grow healthily the Sau is preferable to other trees now in common use. Where canker is prevalent, the Koroi will do better, and in other respects is nearly as good for tea. In places where shade is extremely difficult to establish, Derris robusta is recommended, but in places where other trees grow well *Derris robusta* may grow so vigorously as to damage the tea in its neighbourhood. The Bor medeloa does well and keeps healthy, but is rather slow growing, and very late in coming into leaf.

It is suggested that trials should be made with *Albizzia mollucana*, kept to desired shape and size by pruning.

Dark-leafed tea can do better without shade than tea of light-leafed varieties.

The question as whether shade trees should be planted on a new clearance on good well drained flat land, is not answered.

Available evidence appears to indicate :—

1. Where it is desired to maintain good medium tea at low cost per acre, then shade trees should certainly be used.

2. The, at present, rare case of ideal tea occupying the soil so thoroughly that no jungle can grow under it is one where it is very desirable that the risk of using short-lived trees should be avoided. On normal soil such tea could only be established with the help of high expenditure on manuring and general treatment (including pruning and spraying). In the first few years it would also require very good cultivation and light plucking. When established the cost per acre would remain high, but the demand on labour and the expenditure per pound of tea should be relatively low. Even such tea would probably have to be of dark leafed variety if it is to do without shade.

PRUNING IN RELATION TO DISEASE IN THE SURMA VALLEY.

BY

A. C. TUNSTALL.

THE droughts in the cold weathers of 1922, 1923 and 1924 served a useful purpose in emphasizing the importance of pruning in relation to fungus disease. The effect of the drought was to kill off in one or two years stems and branches which under normal conditions would have taken perhaps ten years to die. In most cases the stems concerned were either dead or moribund before the various stem disease producing fungi attacked them. Once the fungi had obtained a footing the infection spread more or less rapidly to other parts of the bush previously healthy. In many cases however the white ants removed the bulk of the dead and diseased tissue before irreparable damage had been done and very many bushes owe their present existence to the presence of this despised insect. The old style of pruning in the Surma Valley was very simple. It generally consisted in slashing the bushes across their tops. No attempt was made to space out the branches and to remove unproductive wood. The result was that the bushes bore a conjested mass of twigs and moribund wood in their centres. This conjestion was further emphasized by the system of plucking. The bushes were plucked to a more or less conical shape. This encouraged growth in the centre where there were already too many branches and the sides where there was plenty of room for growth were plucked down and prevented from expanding. In the course of time the bushes became unwieldy and it was necessary to cut back. This cutting back consisted in an unusually low slash across the bush. After this operation if the bush was fortunate the top portion died sufficiently slowly to allow of the production of new growth from the collar. The old wood gradually decayed away and a new bush remained still alive though smaller and less productive than the old one.

The droughts of recent years accelerated the death of the old wood and in many cases the bush died right out before new

growth had been made. The immediate cause of death was in general stem disease.

The fungi concerned in causing stem disease were the wood destroying fungi commonly found in the surrounding jungle. Fungi which do not as a rule attack living tissues.

A cut in old hard wood heals very slowly unless it is made adjoining a young vigorous branch. The longer a cut takes to heal the more liable it is to become diseased. Unfortunately the bushes have grown so high that in many cases a reduction in height is necessary. Where the frames of the bushes are in good condition it is possible to avoid cutting right back onto thick old wood by pruning close to a young stem immediately below the previous year's pruning. If this is continued annually for a number of years the bush will be gradually reduced in height and all the pruning cuts will be in the neighbourhood of vigorous growing wood—where the chances of infection by stem diseases are very much less. In the meantime new shoots will continue to form lower down. The chances of infection are further reduced as pruning cuts made one year will be removed in the following year.

Where the old frames are unsatisfactory and more or less moribund cutting back to old wood cannot be avoided. Severe cutting back on old frames ultimately leads to the death of the bushes. After a number of years the infection of the old unhealed wounds takes place and spreads and spreads until the whole bush dies. By careful management however it is possible to prolong the lives of the bushes for a considerable time.

If the bushes cut back in previous years are examined and compared it will be found that the diseases attack the conjested centres first. This not only applies to old bushes but also to young ones. Another general rule is that the higher the cut is made on old hard wood the more liable it is to disease. This is probably due to the fact that the cut is nearer the plucking level. In consequence the growth above the cut is restricted and the resulting branches are in consequence less vigorous.

A great deal of disease can be avoided by going over the bushes again after the new shoots have appeared. The old stems should then be cut back to a vigorous shoot. This will prevent the formation of many snags.

The cutting back of the old frame and the inducement of new growth from the collars is only the beginning of the process of renovation. If the new growth be allowed to grow straight up through the old frame the conjestion in the centre will return in a few years and both the growth on the frame and on the younger wood will be seriously interfered with and eventually diseased. Instead of allowing the new shoots to grow straight up to the general plucking level they should be cut back to 8 or 9 inches in their first year of growth and induced to produce branches to the outside of the bush. The old centre is gradually cut right away and a new frame will be there to take its place. This frame gradually closes up in the centre and a succession of new shoots arise round the outside. If these are treated the same way there will always be new branches to take the place of the older ones in the centre which have passed their prime.

In the case of young tea the same process can be applied. As new shoots arise lower down the stem the centre should be cut lower and lower each time cutting close to a vigorous young stem if possible until it is finally cut right out. As it is often impossible to cut near a new vigorous shoot it is necessary to go over the plot a second time when the new shoots have commenced to grow. The branches which have not broken away at the cut should then be cut back to a shoot. If this is not done the portion above the shoot will certainly cause trouble sooner or later. If the new growth from the collar be pruned to 8 or 9 inches from the ground when the thickness of a finger, side branches will be formed increasing the spread of the bush. As these sides close up round the centres the older branches now in the centre can in many cases be cut right down. In this way the bush may be trained so that there may be a constant succession of healthy vigorous stems.

If this system is worked out properly severe cutting back on to old wood is avoided altogether and the risk of stem disease reduced to a minimum.

Old wood is much more prone to attacks of disease than young vigorous wood and the aim should be to avoid the necessity for cutting old wood as much as possible. A branch should not be allowed to remain past its prime. By careful management on the lines suggested above it is possible without unduly reducing the crop to cut each branch right out before it becomes old and moribund.

The system of plucking commonly employed on Surma Valley gardens is also conducive to conjestion in the centres of the bushes. A few gardens have introduced flat plucking with considerable success. This system besides being easier to control tends to develop the sides of the bush reducing the growth of wood in the centre.

It may possibly be thought from the above remarks that it is suggested that the systems of pruning and plucking in vogue in the Assam Valley should be employed in the Surma Valley. This is incorrect.

Experience has shown that in those districts which have relatively low humidity for a comparatively long period in the year severe pruning and hard plucking do not pay.

In the cold weather in the Surma Valley the air is much drier than that in the Assam districts particularly in Upper Assam. In the latter district it is possible to prune bushes absolutely clean without undue loss in crop. Bushes similarly treated in the Surma Valley would take half the following season to recover. This may possibly be due to the effect of the humidity of the air on transpiration. In dry air a smaller leaf area is necessary for the evaporation of excess water and in consequence the plant is not stimulated to increase the area so much as it would be in damper conditions.

The question of the treatment of pruning cuts has been dealt with a number of times in this journal. Burgundy paste is now frequently used for this purpose but it should be pointed out that no practicable treatment will prevent a moribund stem from dying back and eventually becoming infected by fungi. The Burgundy paste or in fact any other fungicide will only prevent infection for a time. It would appear that the healing of the wounds is delayed by the application of concentrated fungicides and unless there is a special reason such as the presence of stem disease the use of fungicidal pastes, etc., on wounds is not advocated. Under ordinary conditions it is better to spray the bushes immediately after pruning with Lime sulphur solution, see Quarterly Journal, Part III, 1925. The satisfactory healing of a wound depends largely on moisture. Where the atmosphere is moist throughout the pruning season as it is in Upper Assam wounds heal readily but in the Surma Valley the air is too dry at that time and healing is considerably delayed. For large wounds a paste of cowdung and earth similar to that used for covering walls makes a covering which stimulates the growth of callus. In this connection it is interesting to note that in an experiment carried out on a garden near Tocklai, by Mr. MacGregor, Scientific Officer of the Jorehaut Company, large pruning cuts were treated as follows:—Untreated, painted with Burgundy paste alone, painted with Burgundy paste and covered with cowdung paste, covered with cowdung paste alone. The treatment with cowdung paste alone gave the best results as regards formation of callus.

The best and in fact only way to prevent stem diseases is by scientific pruning—pruning based on scientific observation. No hard and fast rules can be laid down as each section differs from its neighbour, but the planter must himself observe the response of his bushes to the pruning and draw his own conclusions therefrom as to the best method of attaining the ideal on the various sections of his garden.

A. C. T.

SOIL SURVEY.

THE TERAI.

BY

C. R. HARLER.

THE tea district known as the Terai is a small area almost wholly included within the Siliguri sub-division of Darjeeling. One or two gardens to the north are in Kurseong and some new gardens are being put out in Purnea to the south. The area under tea is about 20,000 acres. From north to south the Terai measures about 16 miles and the same distance from east to west.

The Terai is one of the oldest tea districts in North-East India and after the industry was established as a commercial enterprise in Darjeeling in about 1856 attention was then paid to the Terai where the first garden was put out at Champta in 1862. The lands east of the Teesta were soon after explored and Gajaldoba was planted in 1874, followed later by Phulbari (Leesh River). As the tea area spread eastwards till it ultimately reached the Sankos, the boundary of Assam, good jat indigenous tea was planted in place of the China bush with which the Western Dooars and the Terai were planted. In later years the China tea in the Dooars was uprooted and replanted and now there is practically no tea of that jat in cultivation. In the Terai however there are still considerable areas of China and poor hybrid tea.

During the latter years of the War fresh areas were opened out in the Terai only to be abandoned during the 1920-21 slump. These areas are now brought back into cultivation but it is doubtful whether they will ever make first class clearances. During

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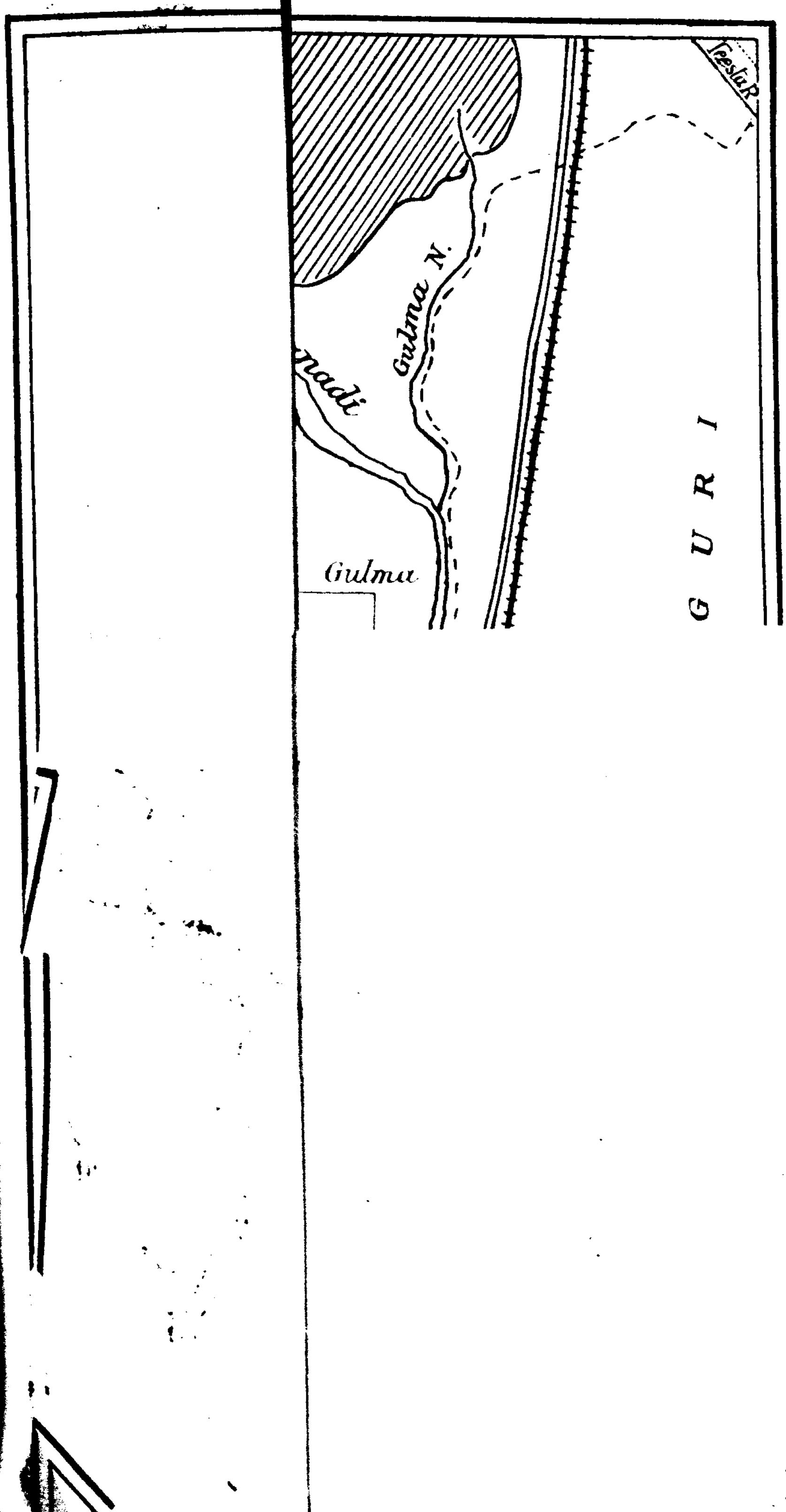
Mem. Ind. Met. Dep., Vol. XXIII, pt. VII.



formed by the Mahaldiram and Mim ranges and is only a small

Burrard and Hayden.

Mem. Ind. Met. Dep., Vol. XXIII, pt. VII.

the past year or so, many fresh concerns have been started generally on poor sites requiring generous treatment to render them suitable for tea.

Geography and Geology.

The Terai is bounded on the north by the Darjeeling foot hills, on the west by the Mechi forming the Nepal frontier, on the east by the Mahanaddi and on the south by the Purnea division of Behar. The word *terai* comes from the Persian and signifies damp. The term may be applied to the strip of country lying along the total length of the foot-hills of the Himalayas, but so far as the tea industry is concerned it refers to the area at the immediate foot of the Darjeeling hills.

Hooker, in his Himalayan Journals, introduces the Terai as follows :—" Siligooree stands on the verge of the Terai, that low malarious belt which skirts the base of the Himalaya from the Sutlej to the Brahmakoond in Upper Assam. Every feature, botanical, geological and zoological, is new on entering the district. The change is sudden and immediate : sea and shore are hardly more conspicuously different; nor from the edge of the Terai to the limit of perpetual snow is any botanical region more clearly marked than in this, which is the commencement of Himalayan vegetation."

The Terai is drained by the Mechi, the Balasan and the Mahanaddi. The Mechi rises under the Rongbong spur on the Nepal frontier and eventually flows into the Mahanaddi in Purnea. The Balasan rises a few miles from Darjeeling, south of the Ghum range and after gathering the Rongbong and the Rinchingtong just below the tip of the Nagri spur, runs into the Terai between Longview and Panighatta. This river has played an important part in depositing the soils of several Terai gardens. Near Tirrihana the Balasan divides into two streams the lesser of which, the Old Balasan, flows south to join the Mahanaddi in Purnea. The main stream, the New Balasan, receives the Rakti and the Rohini on its left bank and flows into the Mahanaddi near Siliguri. The Mahanaddi drains the valley formed by the Mahaldiram and Mim ranges and is only a small

river till it receives its tributaries in the plains. It eventually flows to the Ganges.

The Teesta, although it flows for a short distance through the Terai, receives no tributaries from this area. Like many of the great Himalayan rivers the Teesta rises on the far side of the mountains and its gorge cuts the main range transversely. The Teesta flows into the Brahmaputra and the Baikuntpur Jungle Mahal therefore forms the water-shed in the Terai between this river and the Ganges.

On entering the hills from the Terai one cannot help but notice the frequent changes in rock formation. Immediately after leaving the plains the rocks are of massive sandstone which are soon followed by green and grey silky slates with an occasional outcrop of powdery coal. All these rocks are of a sedimentary nature and comprise what is known as the sub-Himalayan zone. Following these come the granites and crystalline rocks forming the core of the bulk of the ranges constituting the Himalaya proper and stretching from end to end of the mountain chain.

A brief summary of the geological history of northern India and the Himalaya will give some idea of the significance of the various rocks met just north of the Terai.

At the earliest time of which we have any record, long before the Himalayas were formed, much of what is now peninsular India and probably part of the area now occupied by the Himalayas, was covered by the Purana Sea. Owing to the elevation of the land this area became dry and the sea retired to the north to the area where Tibet is now located. The sea remained there from early times (the Cambrian period) till the middle of the Tertiary epoch, a comparatively recent date in the geological time scale, when the Himalayas came into being. This sea after it moved north was probably continuous with the sea which is now represented, in a shrunken form, by the Mediterranean. This water area is known as the Tethys.

At the beginning of the Aryan era in the geological history of India, this country was definitely established as part of the continent of Gondwanaland extending to what is now South Africa on the one hand and Australia on the other. We are now able to picture the Gondwana continent to the south and the Tethys ocean to the north with what is now the plains of northern India forming the southern shore of the sea. Local oscillations occurred and the sea advanced and retired from time to time leaving evidence in the way of rocks and fossils to act as a guide in piecing together the geological history of this area.

Later on (the Jurassic and Cretaceous periods) the Tethys began to shallow owing to the gradual rise of the land in the Tibetan zone and the sea spread into Assam and other parts of India. About this time the Gondwana continent began to break up and the sea came between Africa and India, which latter area tended to become a separate entity.

During the Tertiary epoch came the great period of mountain building. Owing to many causes, among which may be quoted the contraction of the earth and the slowing down in the rate of the earth's rotation, there was a great horizontal thrust from the north and the sediments of the vast Eurasian sea or Tethys were forced against the shores of the once continuous Indo-African continental mass which stood like a buttress in face of the advancing earth waves. As the crests of these earth waves rose from the waters of the sea they were eroded by rain and weather and the rising land became broken and irregular. Drainage basins were carved out on the flanks of the new land mass and a system of rivers composed of transverse valleys was gradually formed. During these disturbances the northern part of India sank and the hollow was subsequently filled up with silt to form what we now know as the Gangetic plain. In many places in the vicinity of the upheaval, molten material was forced up from down below and partly absorbed or metamorphosed the original sediments. In this manner sandstones became quartzites, shales became slates.

We now have the granites and crystalline rocks of the Himalayas fringed with a chain of washings from these rocks. These washings are the sandstones known as the Siwaliks which are often separated from the Himalayas proper by low valleys or *duns*. In the Terai the sandstones belong to the lower Siwaliks and are also known as the Nahan stage because they were first studied at Nahan.

Mixed with the sandstones are the older rocks of the ancient Indian peninsular consisting of rocks of the Damuda and Daling series. Both these series are well known in India and their presence, albeit only in narrow strips, along the Himalayas is taken as evidence that the floor of Gondwanaland once reached where the Himalayas now are. The Damuda rocks are coal bearing and are similar to those met in the Bengal coal fields. The Daling rocks are Archæn and much older than the Damudas. Both these series are separated from their main location by the new alluvium of the Gangetic plain.

It might be thought that the rocks would appear in the order of their age and that the Nahan sandstones, being washed from the Himalayas themselves would abut against the hills and overlie the Damuda rocks followed by the Daling rocks. However, disturbances have been so frequent that complete overfolding has taken place and the Daling rocks now rest against the granite of the Himalayas and overlie the Damuda and Nahan rocks. The change from the ancient Daling rocks to the granite is seldom clearly defined although on the Badamtam spur below Darjeeling the two series are sharply demarcated. In some places, *e.g.*, Pashiting, isolated outcrops of Damuda and Daling rocks appear in the centre of granite.

The relationship of the Terai soils to the rocks in the adjacent hills will be discussed later on.

The Climate of the Terai.

The Terai is the most westerly plains district in North-East India where tea is grown. The reason for this is partly because the Nepal boundary marches with the western edge of the Terai and

any land available is far from the hills. Quite apart from this however, the climate becomes increasingly difficult for tea as we proceed westwards. In Kumaon, Dehra and the Kangra Valley districts tea is grown in the hills where the humidity is greater than in the plains. In spite of this however Assam bushes do not thrive in these districts and the more hardy China bush is preferred.

In the Terai the humidity diminishes appreciably from north to south as does also the rainfall. The critical period of the year is the first five months and unless the rainfall is sufficient during this season the crop is almost invariably a small one.

The general air-flow from the Bay of Bengal, from which direction the rain comes, appears to turn eastwards somewhere in the vicinity of the Terai the result being that from west to east there is a steady increase in rain till finally at the head of the Assam Valley conditions are wholly reliable and a severe drought such as is known in the Terai or the Dooars, never occurs. Even over a short distance either side of the Terai the difference in rainfall is most marked. The table below shows the average monthly rainfall from January to May at Darbhanga, Kisangunge and Dhubri, stations located at about equal distances from the hills. Darbhanga is in Behar about 150 miles to the west of Kisangunge and Dhubri is in Assam about 150 miles to the east.

Station.	Jan.	Feb.	March.	April.	May.
Darbhanga	0·50	0·48	0·46	0·71	2·53
Kesangunje ...	0·50	0·63	0·82	1·94	6·40
Dhubri	0·39	0·72	1·74	5·22	15·22

If stations nearer the hills are considered a similar gradation is seen. Thus Siliguri and Kalchini are similarly placed about 60 miles apart. No figures are obtainable for stations

west of Siliguri for the Nepal frontier comes down into the plains a short distance to the west of that station.

Station.	Jan.	Feb.	March.	April.	May.
Siliguri	0·38	0·70	1·24	3·60	10·79
Kalebini	0·34	1·09	2·00	6·08	15·20

Although the general rain drift is into the Assam Valley the Darjeeling hills and Sikkim receive copious rainfall. The Himalayas act as a barrier, however, and the average annual precipitation in Tibet is only about 8 inches.

The average monthly rainfall at Longview and Siliguri may be taken as indicative for the north and south Terai, respectively.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Longview	0·43	0·69	2·34	4·22	11·35	39·89	37·01	29·57	23·30	6·40	0·50	0·15	146·75
Siliguri	0·38	0·70	1·24	3·60	10·79	25·40	33·40	27·47	21·44	6·08	0·43	0·10	131·03

In the Terai unpruned tea is more of a gamble than in other districts where the drought is not likely to be so severe. In order to obviate the effects of the drought, tea should be pruned and pruned early. Tea which is late-pruned has already drawn much moisture from the soil so that when the spring flush comes there is the possibility of insufficient moisture left for the bush to carry on. Another point to be observed in a drought area is the importance of putting in the deep hoe early and following it up with a mulch hoe. It sometimes happens that a good fall of rain in January does more harm than good in that it destroys the mulch and subsequent drying leaves the soil much drier than it would have been had there been no rain. After early rain it is necessary to hoe in order to re-establish the mulch.

The drought should not be looked upon as an unmixed evil in the Terai for the fierce sun during the early part of the year

does much to arrest the spread of fungus diseases. Although snags may be formed after heavy pruning in the Terai they seldom get *Poria* although in Upper Assam where the climate is more humid, a snag often contracts a disease which eventually brings about the death of the branch. Light prunings may be left on the soil as a mulch in the Terai for the sun carries on sterilization much more effectively than were the prunings partially covered with soil.

The question of shade as an alleviation of the drought is a vexed one for observations in the field supply contradictory evidence. In a garden short of labour shade usually pays, for any loss of soil moisture due to the trees is more than compensated for by the absence of thatch and jungle. In planting shade the jat of the tea is also a point to be considered for a delicate, light leaved bush requires shade much more than a Manipuri plant.

The Classification of Soils.

The study of soils and their classification from an academic point of view has in the past been somewhat neglected because of the close relationship between soils and practical affairs. The tea soils of North-East India have been classified according to their mechanical constitution, a scheme, although of some practical use tells us little from the scientific point of view.

In the formation of a soil from rock, the first process is one of mechanical disintegration. This is followed by the addition of organic matter and the entry of soil bacteria, fungi and other micro-organisms. Chemical weathering follows and this process is favoured by high temperatures, good aeration and a supply of carbonic acid gas supplied partly by rotting vegetation. Silicates are broken up during chemical weathering and oxides of iron are liberated.

The next process in tropical countries like North-East India where the rainfall exceeds the evaporation of moisture from the soil, and the general water movement is downwards, is the leaching out of soil substances in solution. This leaching process

may be followed in all its stages in our tea soils. When the soil is newly deposited it contains a certain percentage of lime and the absorptive capacity of the soil is small. The acidity of such a soil (determined by the Hopkins method) is small. As the leaching process continues, lime and other bases are removed and the acidity increases. Thus new soils are more liable to change than old soils which, from the chemical viewpoint, are more or less stable.

In the Terai and the Dooars it is possible to distinguish between three broad types of soil—the Red bank, the Mal sand and the Grey sandy loam. The Red bank is formed from weathered rocks of the Nahan series and Sikkim gneiss. These soils are well aerated and weathering has brought about the removal of a large percentage of silicates and lime and a liberation of red iron oxide which gives the soil its characteristic colour. The acidity of Red bank soils is generally high.

The Mal sand is a sedimentary soil washed from the hills and characterised by its high percentage of coarse sand and its richness in organic matter. The position of the Mal sands along the foot of the Himalayas is such that they are not naturally well drained and aerated. The result has been an accumulation of humus which owing to its decomposition in the absence of air has produced acids. The downward movement of these acids removes iron to a lower layer and leaves a bleached stratum of soil a foot or so below the surface. Instances of this can often be seen if virgin soil is turned.

If soils of the Mal type are well aerated as is the case on the bank at Bagdogra, the chemical changes proceed differently and a red soil results. The unaerated Mal sand may be said to be a *progressive* type of soil, which tends to accumulate plant food as opposed to a well aerated soil which tends to slowly lose plant food.

The Grey sandy loam is formed mainly from the old rocks of the Daling and Buxa series. These rocks were at one time

clays which have been submitted to great pressure and heat with the result that the colloidal or sticky property of the clay has been lost. The Grey sandy loams act as silts rather than clays, even in their heaviest form. Another point of interest is that these loams formed as they are mainly from the washings of mature clays are incapable of changing to very red soils.

Broadly speaking, our manurial suggestions are based on the soil type as outlined above supported by the mechanical and chemical analyses.

The method of nomenclature for the mechanical texture of a soil is shown below. The five fractions, coarse and fine sand, silt and fine silt and clay are numbered 1 to 5. In naming a soil the fractions are denoted by their numbers given in order of magnitude of the fraction. The table below illustrates this and also gives common examples of the three groups of soil.

Fraction.	Fraction No.	Red bank.	Mal sand.	Grey sandy loam.
Coarse sand ...	1	21	46	15
Find sand ...	2	13	28	14
Silt ...	3	17	9	28
Fine silt ...	4	11	11	24
Clay ...	5	28	3	13
	Type	5, 1, 3, 2, 4	1, 2, 4, 3, 5	3, 4, 1, 2, 5

The Terai soils.

Generally, the Terai soils are sandy and open and easy to work. Most of them are sedimentary soils washed down from the hills, although some of the soils in the northern part of the district have been formed *in situ.*

The oldest soils or the most weathered are those near the hills where the Nahan sandstones form the parent rock. These soils are a type of Red bank resembling some of the soils in the Chalsa and Nagrakata districts of the Dooars. Such soils occur

on Longview and Rohini. Spurs of red soil jut out into the plains and in one place reach as far as Putinbari. This particular spur proceeds from Rohini, through Simulbari to Kaprail where it is cut by the Rakti, but re-appears on the other side of that river at Putinbari. Adalpur, an out-garden of New Champta, is also on a spur of red soil running out from Nijkuman. The other spurs towards Sukna are occupied by forest.

For the rest, the Terai soils are mainly silts and sands washed down from the hills. The Balasan has played an important part in soil deposition and near the main stream, and in the general direction of the Old Balasan, soils of the Mal sand type are encountered. Marionbari, Tirrihana, Ord and the Delka forest are typical of the Mal sand. The further from the main bed of the Balasan the heavier the soils become. The river has changed its course many times as is evidenced by stony ridges in many gardens and the area covered by Mal sand is considerable.

The Mechi also has been responsible for the soils on several gardens, namely, Lohagarh and some of the gardens near Naksalbari.

The formation of the Terai soils has probably taken place in several phases and the floor of the district may have been raised or lowered from time to time. A low sandy bank of reddish soil, terminates near Matigara Bazar and is surrounded by a silt brought down by the Mahanaddi. The red banks to the south of Bagdogra are in many cases of the same mechanical formation as the black Mal sands of Tirrihana and Marionbari. It may be assumed that these banks were raised after the soils had been formed.

The Longview and Rohini soils may be considered together for the red soils are closely related and are of the 1, 3, 5 type which signifies that coarse sand, silt and clay are major fractions. This is a combination difficult to explain, for

a sedimentary soil tends to show a steady gradation in its fractions whilst a weathered soil tends to accumulate clay at the expense of the coarser fractions. The 1, 3, 5 type is met along the line Zuranti, Nagaisuri, Nagrakata, Kurti, Luksan and Chengmari in the Dooars. To the north and south of this line the soils are of the normal 1, 5 or 5, 1 type of red bank as shown below in the first Nijkuman sample.

The table below shows the percentage of each soil fraction and the soil type. The loss on ignition is some measure of the organic matter in a soil although, with some soils, it is largely a measure of the water of constitution of the soil.

Soil.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Type.
Longview—							
Munshitar ...	32	14	19	8	11	13·6	1, 3, 2, 5, 4
" ...	26	17	22	8	13	12·63	1, 3, 2, 5, 4
Kalabari ...	14	13	31	3	26	10·39	3, 5, 1, 2, 4
Bissurbatti ...	16	9	32	3	29	11·19	3, 5, 1, 2, 4
Gotpakha ...	25	16	24	5	22	7·48	1, 3, 5, 2, 4
Fallodhi ...	40	12	13	11	10	12·78	1, 3, 2, 5, 4
Rohini U. D. 1 ...	30	10	28	2	21	9·35	1, 3, 5, 2, 4
" M. D. 2 ...	33	11	26	1	13	14·97	1, 3, 5, 2, 4
Nijkuman ...	22	12	14	15	27	9·17	5, 1, 4, 3, 2
" ...	11	14	22	12	31	8·61	5, 3, 2, 1, 4

Fallodhi is not a Red bank type. It is interesting to note that part of Munshitar together with Sathbhaia are the only two tea areas in the Terai where mica is not present in the soil in an easily distinguishable quantity.

The soils from Potong, the hill garden connected with Panighatta, are worthy of note. Part of the garden is put out on Nahan sandstone and part on the Daling rocks. The soils are of different texture and look different. The soil above the sandstone is sandy whereas that above the Daling rocks has the greasy

feel associated with a silt. The mechanical analysis however shows the soils to be very similar.

Soil.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Type.
Potong No. 6, Sandstone	8	36	19	20	7	6·86	2, 4, 3, 1, 5
" " 2, Daling rock	12	39	20	19	7	9·97	2, 3, 4, 1, 5

This is a case where the mechanical analysis fails to distinguish between soils obviously different.

Considering now the soils of the Mal sand type, the most noteworthy feature is that after coarse and fine sand the next fraction is usually fine silt. It is difficult to believe that this type of soil is deposited by running water and it is also strange that weathering should bring about the accumulation of the penultimate fraction—the fine silt, No. 4 fraction—and not the clay. One explanation is that the rocks from which these soils originate are, in part, clays which have been submitted to great heat or great pressure and have thus lost the property of weathering back to true, colloidal clays but remain at the fine silt stage.

The Mal sands are the richest of all the tea soils of North-East India.

The table below gives some typical soils from Marionbari, Tirrihana and Ord.

Soil.	Coarse sand.	Fine sand	Silt	Fine silt.	Clay.	Loss on ignition.	Type.
Marionbari ...	39	20	14	19	5	9·90	1, 2, 4, 3, 5
" ...	47	14	5	13	10	8·64	1, 2, 4, 5, 3
Tirrihana	50	8	5	18	8	8·29	1, 4, 5, 2, 3
Ord	43	22	6	14	7	7 62	1, 2, 4, 5, 3
" Kadma ...	27	32	12	13	10	5·08	2, 1, 4, 3, 5
" " ...	42	21	5	15	6	9·30	1, 2, 4, 5, 3
M. M. ...	53	16	5	11	5	8·55	1, 2, 4, 5, 3

The Terai flat of Longview is also a Mal sand as is also Subtiguri, an out-garden of New Champta put out to the south of Marionbari on a low bank between the Balasan and the Rakti.

Below Subtiguri is a small garden, Phulbari, put out on a silt of the grey sandy loam type, deposited by the Rakti. The Rakti is only a small river bringing deposit almost wholly from rocks of the Daling series. The lower portion of Putinbar is a soil similar to Phulbari.

The soils of Kamalpur, Hindu and Deomoni put out to the south of the Delka Forest are of the heavier Mal sand type.

Lohagarh is an interesting garden planted out on the flood plains of the Mechi. It is almost surrounded by hills composed of Nahan sandstone. On the southern flank of Lohagarh hill is an outcrop of iron. The ore however is of poor quality varying from a strongly ferruginous clay to an impure brown haematite.

At Panighatta the soil was laid down by the Balasan and the type resembles that at Lohagarh deposited by the Mechi. The gardens to the south, Manja, Morapur, Belgachi together with Jhabra, Nipania, Ashapur and Merry View are all of the heavier Mal sand type. As this type develops, the 1, 2, 4, coarse sand, fine sand, fine silt, gives place to 2, 1, 4, fine sand, coarse sand, fine silt, and eventually the coarse sand ceases to be a major fraction and the 2, 4 type is evolved. These types are included in the analyses below.

Soil.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Type.
Lohagarh	13	26	17	24	9	9·91	2, 4, 3, 1, 5
Panighatta ...	18	16	16	25	11	10·32	4, 1, 3, 2, 5
Manja	26	43	11	10	6	3·56	2, 1, 3, 4, 5
Morapore	24	35	11	15	5	8·36	2, 1, 4, 3, 5
Belgachi	21	23	13	23	14	5·11	2, 4, 1, 5, 3
Ashapur	23	36	13	14	9	3·79	2, 1, 4, 3, 5
Merry View ...	33	31	12	11	2	8·4	1, 2, 3, 4, 5
,, ,, ...	11	43	19	16	5	4·72	2, 3, 4, 1, 5

On the east of the Balasan in the area influenced by the Mahanaddi are many interesting soils. Most of the soils here are extreme cases of Mal sands of the 2, 4 type and in some cases they are silts with fine silt as the major fraction. These latter soils are of the Grey sandy loam type. In all the soils mentioned below fine silt is a major fraction.

Soil.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Type.
Mohurgong ...	18	27	16	19	9	8·36	2, 4, 1, 3, 5
Gulma	11	49	8	18	6	5·97	2, 4, 1, 3, 5
"	15	36	13	30	2	2·56	2, 4, 1, 3, 5
Sukna	7	67	5	12	3	3·93	2, 4, 1, 3, 5
Panchanai ...	15	37	13	19	9	8·80	2, 4, 1, 3, 5
Salbari	9	17	18	32	15	6·48	4, 3, 2, 5, 1
Wingfield	14	13	21	26	15	8·58	4, 3, 5, 1, 2
Chandmoni ...	3	20	28	34	10	4·89	4, 3, 2, 5, 1

Matigara yields some interesting types which resemble rather the silts of the Mahanaddi than the sands of the Balasan. Four very definite types are present.

Soil.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Type.
Matigara	23	31	18	8	10	7·23	2, 1, 3, 5, 4
"	61	15	7	5	6	4·30	1, 2, 3, 5, 4
"	37	28	8	12	7	5·70	1, 2, 4, 3, 5
"	14	31	16	19	14	6·18	2, 4, 3, 1, 5

This garden, like others on the same area is difficult to drain for it is below the gentle sloping land of the Terai proper and hence receives the seepage waters from the north.

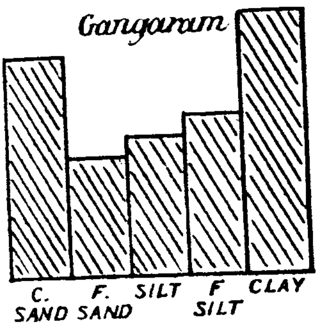
The gardens put out in the south Terai, *i.e.*, south of the railway line, are generally situated on banks of red or reddish soil. These soils show a wide variation. Thus at Sathbhaia is a clay, the heaviest in the Terai. At Pahargoomia the soil is a light, friable sand. At Bagdogra it is generally a red Mal

E TERAI SOIL TYPES

RED BANK

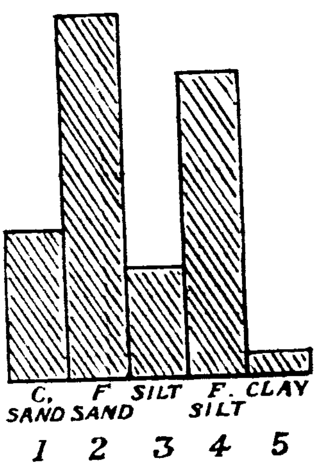
TYPE 51432

Rohini.
Moonee
Gangaram



TYPE 24135

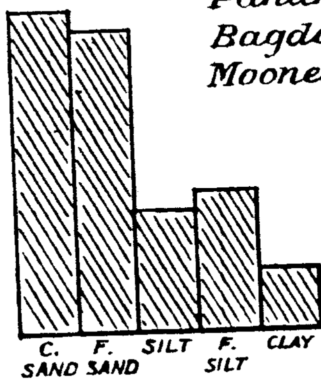
Mohorgong
Gulma
Suhna



SAND

TYPE 12435

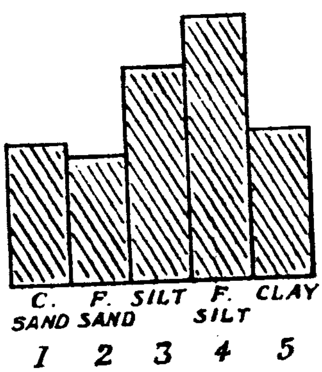
Pahargoomia
Bagdogra
Moonee



GREY SANDY LOAM

TYPE 43512

Wingfield



sand, which type of soil also occurs at Moonee and Gangaram. At the two last named gardens true red bank soils also occur. The banks at Hansqua, Gaya Ganga and Kamala are mixtures similar to those at Gangaram.

Soil.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Type.
Ahmedabad ...	40	14	9	22	8	5·77	1, 4, 2, 3, 5
Sathbhaia ...	7	18	19	24	20	8·47	4, 5, 3, 2, 1
Atal	17	28	18	20	7	7·33	2, 3, 4, 1, 5
Dum Duma ...	45	27	12	11	4	5·26	1, 2, 3, 4, 5
Pahargoomia ...	52	23	12	10	3	5·46	1, 2, 3, 4, 5
,, ...	34	32	12	14	6	5·80	1, 2, 4, 3, 5
Bagdogra ...	21	28	14	15	13	6·49	2, 1, 4, 3, 5
,, ...	57	14	6	10	5	4·78	1, 2, 4, 3, 5
,, ...	37	21	9	15	7	7·11	1, 2, 4, 3, 5
,, ...	14	33	13	19	10	6·98	2, 4, 1, 3, 5
Moonee	14	34	10	16	17	7·79	2, 5, 4, 1, 3
,, ...	30	27	8	14	13	6·19	1, 2, 4, 5, 3
,, ...	24	36	8	13	12	6·38	2, 1, 4, 5, 3
Gangaram ...	43	22	4	13	8	9·05	1, 2, 4, 5, 3
,, ...	18	29	11	17	18	7·00	2, 1, 5, 4, 3
,, ...	30	15	11	18	19	7·39	1, 5, 4, 2, 3
,, ...	34	25	6	13	14	6·97	1, 2, 5, 4, 3
Sahabad	50	17	8	6	10	8·68	1, 2, 5, 3, 4

The chart opposite represents diagrammatically various soil types met in the Terai.

The Treatment of Terai Soil.

The Terai soils like all tea soils in North-East India need organic matter and readily available nitrogen. Although some of the Mal sands are very rich in both these constituents they still respond to further additions. Many of the silty soils can only be worked satisfactorily if they are generously supplied with organic matter. Most of the soils, being sands, will benefit from the addition of potash and a few areas, like Sathbhaia, from additions of phosphoric acid. Where green crops are grown it is advisable to manure with a phosphatic manure.

If labour is plentiful a garden may be put under a manuring cycle based on the following lines :—

1. Cowpeas or dhaincha
   and
   2 cwt. Belgian Flour phosphate.

2. A chemical mixture giving-30 lbs. nitrogen
   30 lbs. potash
   applied with the first rains.

3. Rahar sown in clumps and lopped at intervals.
   Cut down rahar at end of season and bury.
   Mixture as in 2.

4. *Nil.*

This rotation costs about Rs. 15 per acre exclusive of labour. As an alternative Rahar may be replaced by Boga medeloa in which case the crop will be left standing for two years and will be buried in the fourth year. This cycle also costs about Rs. 15 per acre each year.

Trenching should not be necessary in the Terai for few of the soils appear to have pans. In many areas deep cultivation of any kind can be omitted for a season or so unless there is deep rooted jungle to be eliminated.

Although green cropping is the cheapest and most effective way of adding organic matter to a garden and putting new life into a soil, it entails much labour and is not always a success. In the Dooars and the Terai it is often necessary to plant green crops late owing to the drought, so that by the time the crop appears the jungle is also growing at a great rate. The result is a very indifferent crop and jungle which gets out of hand because it cannot be hoed on account of the standing crop. In other cases green crops cannot be grown because the bushes are too big.

On account of these difficulties it is often preferable to add organic matter to the soil in the form of a manure. Organic manures are much more expensive than chemical ones, but if it

is decided not to grow a green crop then organic matter should be added somehow and a suitable two-year cycle is as follows :—

1.	Chemical mixture giving	30 lbs. nitrogen
		30 lbs. potash.
2.	Organic manure giving	30 lbs. nitrogen.

In the chemical manure the nitrogen may be added as 150 lbs. sulphate of ammonia or 200 lbs. nitrate of soda or 160 lbs. nitrolim or calcium cyanamide. Nitrolim is an alkaline manure containing about 50 per cent. free lime. This manure can be used to advantage on heavier soils.

The potash may be given as 60 lbs. muriate of potash.

The organic manure in the second year may be given as 8 maunds oilcake or 5 maunds sterilized animal meal or 5 maunds fish guano. All three manures do well but the last two have the advantage of supplying 30 lbs. phosphoric acid in addition to the nitrogen. Fish guano is costly at present, but the other two may be applied for about Rs. 28 per acre.

THE PACKING AND STORAGE OF TEA SEED.

BY

C. J. HARRISON.

OF recent years the sale of Indian tea seed to planting concerns in Java and Sumatra has increased considerably, and in addition, the exploitation of Kenya Colony as a tea growing district has opened up a new market for Indian seed. Among the many problems which arise in the transport of seed to such comparatively distant localities, not the least important is that of ascertaining the best conditions for packing which will ensure maximum vitality in the seed after a period, extending possibly to four months from the time when the seed was first collected. The usual methods of packing seed for transport employ strong wooden boxes, reinforced by iron clamps. The seed is actually packed in sand, charcoal or clay, which should be slightly damp to prevent desiccation of the seed, but not so damp as to induce germination, or the growth of moulds.

While this type of packing is satisfactory for samples which are to be opened and germinated after a fortnight or three weeks, it has been found unsuitable for seed kept over longer periods. Moulds inevitably make their appearance, and the vitality of the seed is lowered considerably.

A method of packing, which seems to offer many advantages over the foregoing method, has been tried on a small scale at Tocklai and has proved successful in that after six months, seed packed under the particular conditions lost none of its original vitality, and was quite free from mould.

The method consists in sealing up the seed in tins without packing of any sort, immediately after collection from the tea seed garden.

The tins used were Liptons' 1 lb. tea tins, holding about 400 seeds. The seed was taken from a small plot of Borjan

bushes at the Borbhetta Experimental tea garden. Immediately after collecting it was tested and gave the following results.

Sinkers	...	57 per cent.	after 5 minutes immersion.
Floaters	...	43 per cent.	

The sinkers and floaters were germinated and gave the results quoted in the accompanying tables.

In addition to packing in tins, the following methods of packing were tried for purposes of comparison :—

Packing in dry sand	...	(0.14 per cent. moisture)
,, ,, moist sand	...	(4 per cent. ,,)
,, ,, moist clay	...	(16 per cent. ,,)

In each of these three cases no effort was made to exclude moulds or fungi by sterilisation before packing, and as a result moulds had developed to a certain extent on the seeds after keeping one month. After two months the seeds were covered with mould, and their vitality, as measured by percentage germination in a certain time, was very low.

Another interesting point in connection with germination was connected with the "starring" of tea seed, caused by puncture of the seed in its early stages, by the "tea seed bug" (*Poecilocorus latus*). All the seeds which had not germinated after a month or six weeks were opened and examined and more than 90 per cent. were "starred." Of course, many starred seeds germinate more or less normally, though the time taken to do so is nearly always longer than in the case of "unstarred" seed. These facts, taken in conjunction with the fact that a puncture by the "tea seed bug," forms a channel in the seed coat for the entrance of fungus diseases (which are found *only* in "starred" seed), form sound reasons for the eradication of the bug from seed gardens.

With regard to the effect of the size of the tea seed on its vitality, it has been observed that, apart from such considerations as starring, etc., the medium size seed germinates quick-

est; abnormally large and small seeds take longer to germinate, and often do not germinate at all.

On a practical scale, a method of packing seed which is simple and at the same time inexpensive would be to fill clean, dry kerosine tins with dry, freshly collected seed and to solder the tins up carefully so as to make them perfectly airtight. For the purposes of transport two tins can be packed in a strong wooden box just large enough to hold them, and strengthened with a couple of metal bands. This gives a package of convenient size and shape and one which would stand considerable rough usage without giving way.

Another use to which this method of packing could be put, is the storage of seed from October or November, when it is collected from the seed-bari, until about the end of March when it can be planted at stake. Owing to the high percentage germination which is found in samples of seed stored in sealed tins, one could be confident, in planting such seed at stake, that there would be a minimum number of vacancies owing to non-germination. Some of the seed which had been stored in tins for six months in the laboratory and then germinated was planted out under shade and has, after three months, produced sturdy plants.

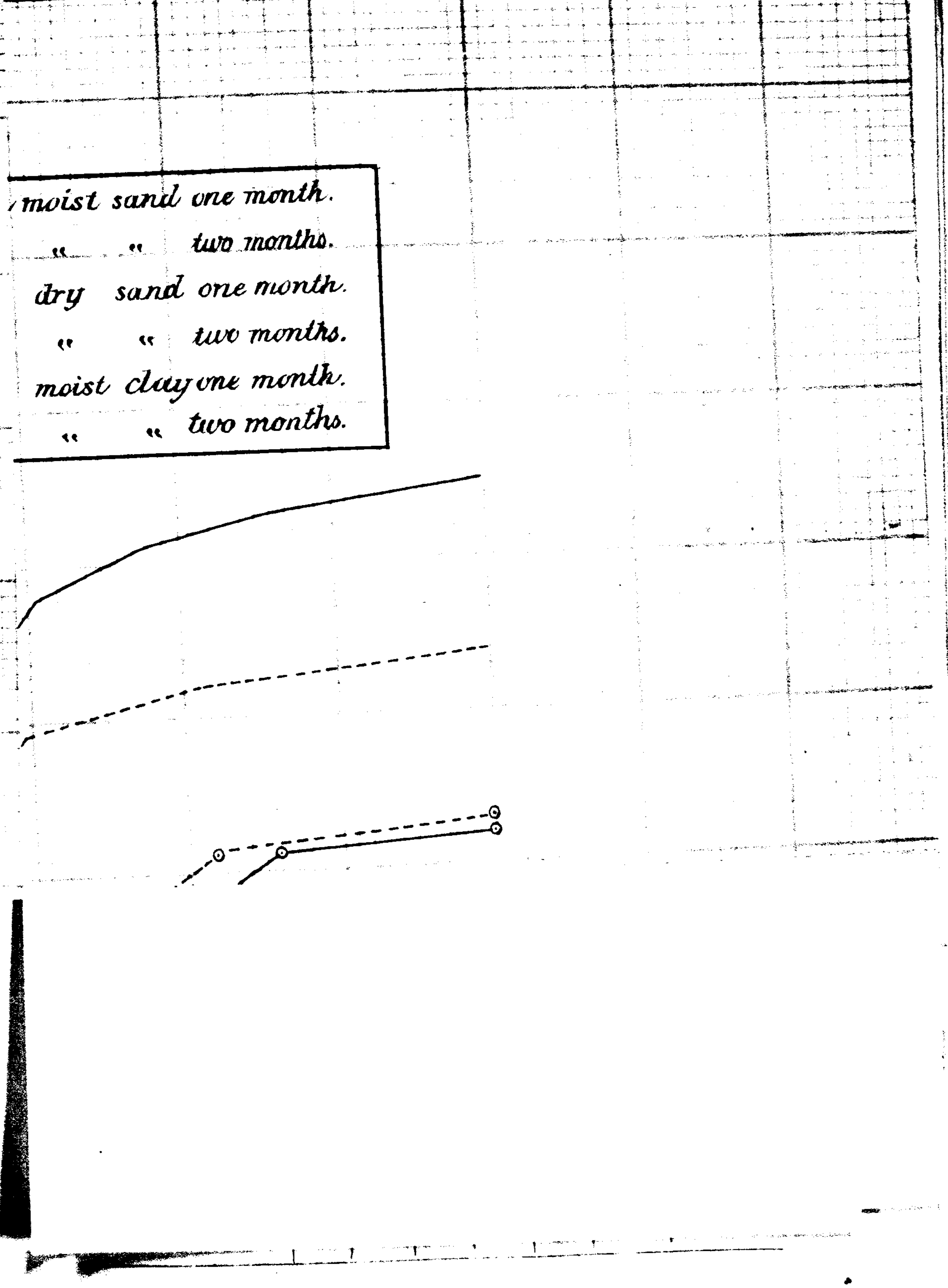
It will be noticed from the table that the seed under experiment when collected had apparently a low vitality, which vitality, as measured by the rate of germination, increased in proportion to the length of time the seed was stored. This is clearly shown in the accompanying set of germination curves, and was no doubt due to the fact that the seed when collected was rather immature, and matured on storage.

As a comparison with the seed samples kept for six months under the conditions described above, two samples of seed—

(*a*) Stored in dry sand

(*b*) Stored in moist clay

a Seed from Clay & Sand Packing



(c) Stored in moist clay

were kept for six months and examined at the end of this period. In the first case the seed appeared good and there were 80 per cent. sinkers. Some fungus or bacteria had however been at work and a vinegar-like odour was apparent. None of the seed germinated even after a month.

In the second case germination had taken place during storage, and on opening the tin there was a mass of twisted rootlets mixed up with clay, seed and fungus growth, rendering the whole sample useless. About 60 per cent. of the total seeds had germinated during storage and the remaining 40 per cent. was rotten.

It is evident that storage of seed in sand or clay is unsuitable for protracted periods, while storage in hermetically sealed tins without any packing material, offers many advantages, not only where the seed is destined for sale abroad but for use where it is desired to plant seed at stake at a time when weather conditions will be most favourable.

Results of Germinating Seed Stored under Different Conditions.

Check Sample--(Germinated immediately after collection).

Sinkers	...	179	—	57 per cent.
Floaters	...	135	—	43 per cent.
Total	...	314		

	Number germinated						Percentage of Total Seeds.
	18 days.	25 days.	30 days.	42 days.	60 days.	Total.	
Sinkers	52	22	7	12	5	98	31 %
Floaters	28	12	3	3	5	51	16½ %

Seed stored in Sealed Tins.

(*a*) *1 month.*

Sinkers	...	339	—	85 per cent.
Floaters	...	59	—	15 per cent.
Total	...	398		

	Number germinated							Percentage of Total Seeds.
	14 days.	21 days.	30 days.	37 days.	45 days.	60 days.	Total.	
Sinkers ..	54	91	50	56	13	33	297	75 %
Floaters ...	1	5	3	5	3	*nil*	17	4½ %

(*b*) *2 months.*

Sinkers	...	330	—	80 per cent.
Floaters	...	88	—	20 per cent.
Total	...	421		

	Number germinated							Percentage of Total Seeds.
	7 days.	21 days.	30 days.	37 days.	45 days.	60 days.	Total.	
Sinkers ...	9	86	138	46	13	*nil*	292	70%
Floaters ...	3	14	10	8	2	*nil*	37	9%

(*c*) *4 months.*

Sinkers	...	330	—	80 per cent.
Floaters	...	89	—	20 per cent.
Total	...	419		

	Number germinated					Percentage of Total Seeds.
	14 days.	21 days.	30 days.	45 days.	Total.	
Sinkers ...	219	82	16	*nil*	317	76%
Floaters	6	10	4	4	24	6%

(*d*) *6 months.*

Sinkers	...	337	—	80 per cent.
Floaters	...	87	—	20 per cent.
Total	...	424		

	Number germinated							Percentage of Total Seeds.
	7 days.	12 days.	20 days.	26 days.	30 days.	45 days.	Total.	
Sinkers ...	227	69	17	4	2	2	321	80%
Floaters ...	7	9	4	7	*nil*	*nil*	27	6%

Seed stored in moist Sand—(4 per cent. moisture).

(*a*) *1 month.*

Sinkers	...	68
Floaters	...	32
Total	...	100

	Number germinated							Percentage of Total Seeds.
	15 days.	22 days.	31 days.	38 days.	46 days.	60 days.	Total.	
Sinkers ...	15	14	11	3	2	2	47	47%
Floaters ...	3	4	1	*nil*	*nil*	*nil*	8	8%

(*b*) *2 months.*

Sinkers	...	94
Floaters	...	6
Total	...	100

	Number germinated						Percentage of Total Seeds.
	14 days.	21 days.	30 days	42 days.	60 days.	Total.	
Sinkers	20	7	10	3	2	42	42%
Floaters	1	0	1	0	0	0	2%

Seed stored in Dry Sand.

(*a*) *1 month.*

Sinkers	...	88
Floaters	...	12
Total	...	100

	Number germinated							Percentage of Total Seeds.
	15 days.	22 days	31 days.	38 days.	46 days.	60 days.	Total.	
Sinkers ...	3	7	8	5	4	1	28	28 %
Floaters ...	0	1	1	1	1	0	4	4 %

(*b*) *2 months.*

Sinkers	...	95
Floaters	...	5
Total	...	100

	Number germinated						Percentage of Total Seeds.
	14 days.	21 days.	30 days.	42 days.	60 days	Total.	
Sinkers	7	6	8	8	2	31	31 %
Floaters	1	1	0	0	0	2	2 %

Seed stored in moist Clay—(16 per cent. moisture).

(*a*) *1 month.*

Sinkers	...	100
Floaters	...	0

	Number germinated							%
	15 days.	22 days.	31 days.	38 days.	49 days.	60 days.	Total	
Sinkers ...	[illegible]	3	0	0	3	2	17	17 %

(*b*) 2 *months.*

Sinkers ... 100

Floaters ... 0

	Number germinated						%
	14 days.	21 days.	30 days.	42 days.	60 days.	Total.	
Sinkers	12	3	6	1	0	22	22%

TEA TERMITES IN CEYLON.*

BY

MR. F. P. JEPSON.

ASSISTANT GOVERNMENT ENTOMOLOGIST.

The Preliminary Report.

The following is a full summary of the preliminary report :—

The subject of tea termites has been placed on the agenda to-day to keep members informed of the present position regarding these pests and to draw attention to the extremely serious nature of the damage which they are causing in some districts. These pests promise to be a very serious menace to the profitable cultivation of tea if there is any marked extension of the area now known to be affected. It is doubtful whether those who are not familiar with the infested areas can have any conception of the wholesale destruction of the bushes for which these insects are responsible. From information received there seems little doubt that these pests are extending their range of activity in the districts concerned. Unlike all other pests of tea in Ceylon the injury caused by a certain group of termites is of a permanent nature, resulting ultimately in the death of the bushes, although this may be delayed for some years following the original infestation, but there is, each year, an increasing destruction of the frame with a resulting diminution of crop until this finally ceases with the death of the bush. It is important to realize that the termites associated with the tea bush belong to two distinct groups causing entirely different forms of damage. The more serious type of injury is confined to the interior of the bush, there being frequently no external indication of internal infestation. The insects responsible for this form of damage live entirely within the bushes which they

* Reprinted from *The Times of Ceylon*, Friday Evening, 9th July, 1926.

infest, feeding on living and apparently healthy tissues. They all belong to the genus "Calotermes." The other group of termites which infest tea bushes, do not feed on living tissue, but upon dead bark and wood, and it is for this reason only that they visit the bushes. These termites have a wider distribution than the first mentioned group and occur on most tea estates, their characteristic mud covering on the main stem and branches of the bushes being conspicuous objects. They are commonly known as scavenging termites, and the injury which they cause is of a secondary and minor nature. Their nests are situated either beneath the surface of the soil or in the mounds commonly known as "white-ant nests." These insects are so well known that the majority of planters understand them to be referred to when tea termites are spoken of and it is probably for this reason that the serious nature of the injury caused by the other group of termites is not fully appreciated. As the scavenging termites are external feeders on dead and diseased wood and as the remedy lies in the elimination of such material rather than in a campaign against the termites themselves, attention has been concentrated upon the first mentioned group which are primary pests of very considerable importance. There are three species of termites which are concerned with direct injury to apparently healthy bushes. They belong to the genus "calotermes," which includes some of the most primitive forms of this order of insects. Termites are social insects living in communities. The members of each colony are of several different forms or castes which are either reproductive or sterile. The reproductive forms may be winged or wingless. The sterile castes are usually composed of soldiers and workers, the former being concerned with the defence of the nest against invaders and the latter with the general economy of the community, such as foraging for food, care of the eggs and young and attendance upon the queen. The queen of most species is enormously distended and resides in a royal chamber attended by her consort. The composition of a "calotermes" colony differs from that of most other genera in that there are

no workers, the duties of this caste devolving upon the larvæ, every one of which, except the soldiers, being destined to become a mature adult of either sex, and of the winged or wingless form.

Function of Winged Individuals.

The function of the winged individuals is to travel from the parent nest and found new colonies. On attaining the adult winged state, and when atmospheric conditions are favourable, these members emerge from the nest in swarms and fly in pairs in search of a suitable place for the foundation of a new colony. The fact that only a small percentage of these individuals succeed in their purpose probably accounts for the comparatively delayed extension of the area infested by these insects. The wingless, or neoteinic, forms are concerned with the maintenance of the original colony. They are of both sexes, are reproductive, and are usually concentrated in one portion of the nest. At present nothing is known of the life history of the Ceylon "calotermes." The life cycle from egg to sexual adult may occupy one, or even two years. It is extremely difficult to follow the various stages in the metamorphosis of these insects when they are working in solid wood where their movements cannot be detected. The dissection of the wood in which they are hidden, in order to follow their development, considerably interferes with their arrangements. It has been found that the substance in the wood which is made use of by the wood-eating termites is cellulose, and this information has led to the artificial rearing of these insects in glass tubes, their food consisting of filter-paper, which is composed of cellulose in a pure form. This method has been adopted here and some insects have been kept alive and active for over nine months. Attempts to induce them to breed in this medium have so far been unsuccessful. A knowledge of the details in the life-histories of insects is often an extremely important aid to their control, as they are sometimes particularly vulnerable at certain stages in their lives. In the case of the insects which we are considering, a knowledge of the season when the colonising flight is expected to issue from the

nest might enable one to frustrate this in some manner and so prevent the foundation of new colonies in uninfested bushes and thus control the further extension of the infested area. An extremely interesting fact in connection with these and other species of wood-eating termites is that all castes which feed on wood harbour in their intestines a large number of minute flagellate organisms. The presence of these Trichonymphids, as they are called, is essential for the welfare of their agency. By incubating the insects to a temperature of 98 degrees F. for 24 hours, these organisms are destroyed and their hosts perish in from 10-20 days owing to their inability to assimilate their food in their absence. It is possible that fact may be put to economic advantage as dry heat alone may suffice to eradicate a "calotermes" colony.

The three species of termites which are destructive to living and healthy tea bushes are "calotermes militaris," "C. dilatatus" and "C. greeni." The first mentioned insect is mainly an Up-country species, the chief sphere of its activity being the Maskeliya district, although its sporadic appearance has been recorded on some estates in Dimbula and Bogawantalawa and on one estate in the Ratnapura district. It has also been found in "grevillea robusta" in Maskeliya and North Matale, and in "Albizzia moluccana" in the former district. Its distribution is probably far more general than present records indicate owing to its insidious mode of attack which may continue for years before being detected.

Information as to its precise point of entry into the bush is lacking. In one instance there was definite evidence that the attack had commenced in the roots, infestation taking place from the adjacent rootlets of a severely attacked bush. Although this may be one mode by which entry is effected, it is almost certain that the winged adults of the colonizing flight gain admittance, above soil level, through wounds in the frame of the bush itself. The injury caused to the bush, whatever the mode of entry, is characteristic, the entire frame being excavated until only a shell remains and the bush succumbs.

The attack of the second species, calotermes dilatatus, is confined, so far as our present knowledge goes, to tea grown at low elevations. This species also is probably far more widely distributed than present records lead one to believe. Entry to the bush, in this case, is undoubtedly effected above soil level and almost certainly through wounds in the frame due to wood-rot. The behaviour of this insect in the bush differs in some respects from that of the Up-country species in that no characteristic central cavity is formed, and only in advanced cases does the attack extend below soil level.

On two estates which have been visited approximately 80 per cent. of the total bushes on each estate are infested and are doomed unless something can be done to save them. A disturbing feature of the situation is that even supplies are being attacked.

The third species of Calotermes attacking tea, Calotermes greeni, is also confined, so far as this crop is concerned, to low altitudes, although it has been found in jungle tree at Peradeniya and in Grevillea in the North Matale District. In size it is the largest of the Ceylon Calotermes and its distribution appears to be extremely limited. Its mode of attack is similar to that of Calotermes dilatatus and any method of control which might be devised for this species would be applicable to Calotermes greeni also.

In regard to the control or these pests there are two distinct problems presented for solution, firstly, the destruction of the infesting colony and secondly, the prevention of reinvasion of the treated bushes and the invasion of those which have not hitherto been attacked.

Destruction of the Colonies.

The destruction of the colonies contained in the interior of the main stem is an extremely difficult proposition. It is, in the first place, not always evident that a bush is infested. If infestation is indicated at pruning time one is still faced with the difficulty of introducing an insecticide which will destroy the

contained colony. In such case there seems no alternative but to drill a hole into the main stem to permit of a toxic material being introduced. In advanced cases of attack by Calotermes militaris there is not the same difficulty, as there is often an exit, from the central cavity to the exterior, of considerable size. This is not the case with the other two species. Certain experiments of a purely preliminary nature have been conducted with the object of destroying the colonies contained within the bushes, but they have not been attended by very successful results. The materials which have been employed were those which were most readily available. The difficulty has been to decide upon a material which is highly toxic to insect life, and, at the same time, be harmless to the plant. Such materials are unfortunately rare. The ideal insecticide for this type of pest is a highly toxic and penetrating gas, and in the case of the Up-country termite, a gas which is heavier than air to enable its penetration to the lower portions of the frame and roots. Two materials which fulfil these conditions have been tested, namely, carbonbisulphide and paradichlorobenzene. The former is a volatile liquid liberating a highly poisonous vapour of penetrating properties on exposure to air. It is two and a half times heavier than air. Dosages of 2 ozs. per bush have resulted not only in the destruction of 95 per cent. of the colonies of the Up-country species, but also in the death of the bushes and tests with reduced doses are to be continued. When injected into bushes attacked by Calotermes dilatatus doses of ½ oz. were fatal to those termites which came in contact with the gas, but the insects in the remoter portions of the nest, or in separate colonies in the same bush, were unaffected. The method of introducing this insecticide was to drill a clean ¼ inch hole into the stem, inject the material and immediately cement the hole. Paradichlorobenzene is a white crystalline substance with an ether-like odour. It vapourises slowly, liberating a highly poisonous vapour which is five times heavier than air. It has been tested against Calotermes militaris in doses ranging form 1/24th to 1/8th ozs., the method of application being to drive a hole into the cavity of severely attacked bushes with an alavangoe, introduce the cry-

stals and plug the holes with clay. It was extremely disappointing to find, after an interval of twelve days, that the termites were unaffected, although they had been compelled to concentrate in one portion of the nest. The tests are to be continued with increased doses as this is an extremely promising insecticide for this purpose. Extensive tests have been conducted by Dr. Brittain, Entomologist to the Government of Nova Scotia, who has recently been on a visit to Ceylon, with a comparatively new insecticide, calcium cyanide, against both Calotermes militaris and Calotermes dilatatus. Calcium cyanide liberates hydrocyanic acid gas when acted upon by atmospheric water vapour. For these experiments the grade known as "A" dust was used, and was applied by means of a specially constructed powerful force pump. It was introduced into the nests of these two species through a clean ¼ inch hole bored into the main stems of infested bushes, the holes being sealed immediately the operation was completed. Termites were destroyed where they could be reached, but those in remote portions of the nests were alive and active when the bushes were subsequently examined. In the Maskeliya district, the practice is in force on some estates, of pouring certain liquids into the central cavities of attacked bushes. The substances generally employed are liquid fuel and a solution of Jeyes fluid, although other solutions have also been used. It is claimed by those who adopt this practice that the method is entirely successful, and the pest can be controlled by this means. Solutions which are designed to kill by contact have the disadvantage of being unable to penetrate all portions of the gallery workings, especially those in the lateral roots. It is true that these solutions, and many others which have not been used, are able to destroy all termites with which they come in contact, but a large number of the insects escape such contact and are able to continue their activities and repopulate the nest. Opportunities have occurred of examining bushes which were alleged to have been successfully treated in this way and in all cases living and active termites were found in those portions of the nest which had not been reached by the solutions. This method of treatment is, therefore, only partially effective, but

perhaps is better than no treatment at all, as there is doubt that many insects are destroyed at a comparatively low cost. If the exact season or seasons of emergence of the colonising flight can be ascertained, this form of treatment might result in the destruction of a large number of individuals which would otherwise be disseminated, and be the founders of new colonies, in previously unattacked bushes.

Preliminary Tests.

The preliminary tests which have been conducted, have indicated that the destruction of termite colonies in the bushes is an extremely difficult undertaking, particularly in the case of the two Low-country species where no central cavity is formed. It is true that in the majority of cases the entire colony of the two species could be removed by collar pruning the bushes as the attacks are concentrated in the higher portions of the bushes. This is a drastic operation which is not favoured at low elevations owing to the heavy mortality of the bushes which is said to follow this practice. It is probable that the mortality is due to rot of the pruned surface, and it is possible that by applying a suitable antiseptic waterproof dressing of a permanent nature immediately after the operation, and by stimulating the growth of the bush with a suitable fertiliser the percentage of mortality might be considerably reduced. The experiment is certainly worthy of trial as in any case an infested bush is doomed to die in due course, and this treatment, although drastic, might endow the bush with a new lease of life if it survives the operation of collar pruning. This treatment would be valueless against the Up-country species as the main colony is situated below soil level and in the majority of cases would leave the entire colony still in the bush. An extremely important aspect of control is the question of protecting the bushes from invasion by the winged individuals at swarming time. This is desirable, not only to prevent the re-infestation of bushes which may have been relieved of their infestation, but also, to prevent the invasion of bushes which have hitherto remained unattacked and consequently to limit the extension of the area now affected by the

pests. It is certain that in the case of the Low-country species entry to the bush is affected well above ground level and almost certainly through the medium of wounds in the frame due to wood-rot. It is extremely probable that the same procedure is adopted by the Up-country species, although infestation in this case may also occur below soil level where the roots of adjacent infested bushes intertwine. It is suggested that a campaign of bush surgery, with its attendant operations of wound dressing and filling cavities, is urgently called for if the further extension of the damage caused by the extremely important pests is to be frustrated. The elimination of such dead and diseased material would also automatically relieve the bushes of the attentions of the scavenging group of termites. The species of tea calotermes form a distinct menace to the tea industry in certain districts and it is extremely important that the seriousness of the position should be fully realised. Some idea of the damage caused to infested bushes may be formed from the samples which have been exhibited.

Further investigations were being made on the subject.

THE

Indian Tea Association.

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL.

PART IV.

1926.

Calcutta:
PRINTED AT THE CATHOLIC ORPHAN PRESS,
3 & 4, Portuguese Church Street.

1927.